accordance with Newcomb's value obtained from other sources. The great difficulty, by which this distinguished man of science found himself embarrassed in this part of his work (see pp. 158-159 of the treatise quoted above), so much so, indeed, that he well-nigh despaired of arriving at a final conclusion as to the value of π to be adopted, has now disappeared. The values for the masses of the earth, $m(♁+☾)=1:327923$, as well as of Venus, $m(♀)=1:414991$, as derived from the secular variations, may thus be accepted with confidence.[1] This is one example showing the theoretical importance of the phenomena here discussed; possibly the results arrived at may be eventually found to contribute towards removing other difficulties still connected with the theory of planetary motions.

We are, it seems to me, fairly warranted in assuming the force acting in such a peculiar way on the motion of the terrestrial pole to be identical with that which exerts its influence on the secular variations. As regards the nature and origin of this force, there is a wide field for speculation. A suggestion to which I was led by a discussion on this subject with my colleague, Mr. G. Clark, of this observatory, and which seems worthy perhaps of further investigation, is that the force may stand in some connection with the still very mysterious phenomena of the earth's magnetism. There is certainly one fact which lends some support to this hypothesis, viz. the eccentric position of the earth's magnetic poles. Joule's well-known experiments on magnetic strain in iron bars suggest the idea that something similar to the molecular displacement in the iron bar may take place in the body of the earth with regard to its magnetic axis. Such a strain along the axis of maximum magnetic moment would almost necessarily cause a displacement of the axis of figure with regard to the axis of rotation. Only so long as the total magnetic potential of the earth was not subject to alterations could this displacement remain constant. In that case the pole of rotation would describe a circle with a *constant* radius round the pole of figure. But there are facts which force us to assume that the potency of the earth's magnetic forces varies with the state of solar activity, and that consequently the molecular displacement in the direction of the magnetic axis varies accordingly. The most striking fact in this respect is the increase of auroræ with an increasing number of solar spots. Now, if we were to consider auroræ as discharges of electric force gradually accumulated in the earth's interior, the strain in the direction of the magnetic axis should have abated after such a discharge, and the pole of figure should therefore approach the pole of instantaneous rotation. This, then, would explain the fact that the semi-amplitude of latitude-variation is smallest after a maximum display of solar spots. How far this hypothesis is able to account for other phenomena brought out by observation must be left to future research.

J. Halm.

Note.—In a very interesting note in *Monthly Notices*, March 1898, Mr. Thackeray investigates the effect of the latitude-variation on the longitudes of the sun as well as on the arc of the obliquity. It appears from his result that the correction to the sun's longitude due to the motion of the pole has an amplitude two and a half times greater than that to the obliquity, cosec. ϵ being almost exactly 2·5. Now from Prof. Newcomb's and Mr. Thackeray's tables showing the corrections to the right ascensions of the sun relative to the stars, as derived from Greenwich observations, I have computed the numerical effect of an error produced in the sun's longitude by an increase from 0 to 10 in Wolf's relative spot-numbers. Assuming Prof. Newcomb's weights assigned to the observations, I obtained $\Delta\lambda = 0''\cdot4457 \pm 0''\cdot0523$, and consequently $\Delta\lambda \sin \epsilon = 0''\cdot1775 \pm 0''\cdot0209$. On the other hand, the value previously found for the obliquity in *Astr. Nach.* 3619, was $\Delta\epsilon = 0''\cdot1703 \pm 0''\cdot0145$. Hence the result that the effect of the force varying with the great spot-period is in point of amplitude exactly analogous to that found by Mr. Thackeray with regard to the phenomenon of latitude-variation. This must, I think, point to the conclusion that those anomalies in the sun's longitude and in the arc of the obliquity which correspond to the great sunspot-period are due to the same force which causes the deviations observed in the motion of the terrestrial pole, that in fact these anomalies are merely another proof of our assertion that the displacement of the pole stands in some connection with the variation of solar activity. The results are derived from two perfectly independent series of observations, the probable errors of $\Delta\lambda$ and $\Delta\epsilon$ being not more than one-tenth of the values obtained; hence the assumption as to the peculiarities elicited from the observations of the sun's right-ascensions and declinations being the result of chance appears to be absolutely untenable.

J. H.

APPLIED METEOROLOGY.[1]

THE name of Prof. Cleveland Abbe is indelibly associated with the onward progress of meteorology in the United States, whether in respect of its commercial and general utility, or on the severer but not less interesting side of dynamical investigation, to which we must look for any theoretical advancement. In the organisation of an immense service, the observations and returns of which cover a large field in the applied science, he has played a yeoman's part; and further, by his translations of many important mathematical papers, he has stimulated study, and given to his countrymen the opportunity of familiarising themselves with the difficult theory which Helmholtz, Hertz, Kirchhoff and others have developed, and on which the perfected science must eventually be based. It seems fitting, therefore, when one of the States—in this case, Maryland—proposes to advance beyond the mere accumulation of meteorological data, and is prepared to foster the study and discussion of special problems connected with climate and its effects, to devote funds for the prosecution of certain lines of research and investigation, that he should be selected to indicate the direction in which study can be most profitably turned with the view of benefiting every human interest. We at least may congratulate ourselves upon the selection, for the outcome has been to collect into an essay of moderate dimensions a list of the most prominent fields of usefulness to which a State weather service can devote itself. We have here a scheme, which though in the first place intended for a particular climate and district, yet is not limited in its scope, and but with few changes may be made to serve as a model for wider areas, and in its fullest application would meet the demands and the necessities of the best instructed meteorologists.

It would be wearisome to give a bare statement of the manifold duties and occupations in which a properly constituted weather service finds itself called upon to take part, and in these pages, fortunately, such a task is not necessary. There may be some who think that weather prediction for shorter or longer periods alone occupies the attention and satisfies the ambition of the meteorologist. To such we commend the list of twenty-nine distinct subjects of enquiry, bearing on every walk of life, assisting every one of the applied sciences, and touching every material interest, that Prof. Cleveland Abbe has put in the foreground of his essay, as additions to the daily storm and weather forecasts, admitted by the least attentive to be the main duty of a meteorological office. But it is needless to say that the author is not satisfied with the mere utilitarian aspect of the science, however valuable the results may be to the agriculturist, the engineer, the mariner, the physician and others throughout the entire circle of the professions. Just as

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[1] This value of the mass of Venus is in close accordance with that derived by Prof. Backlund from the perturbations of Venus on Encke's Comet.

[1] "The Aims and Methods of Meteorological Work, especially as conducted by National and State Weather Services." By Cleveland Abbe. (Baltimore: Johns Hopkins Press, 1899.)
"The Monsoon Forecast." *The Pioneer*, August 10 and October 23, 1899.

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little is he content with that view of popular government, which views favourably the application of scientific results derived from private means and individual enterprise, but does nothing to develop science by research and investigation, on its own initiative. To ask for bricks without providing straw is a complaint that is not limited to one time or one nationality. Prof. Abbe, writing as the adviser of a government prepared to spend its funds on the furtherance of scientific aims, fortunately has not to labour this point; but he nevertheless urges the duty on administrative authority, not only of developing the art of applying the sciences, but also that of constructing them.

The observational side of meteorology has been so long in evidence at the expense of the experimental, that it is very desirable that an eminent authority should insist upon the necessity of experiment and research in physical laboratories, as distinct from the ordinary meteorological observations with which so many observers content themselves. Foremost among the inquiries demanding increased attention, the author places the physical constants pertaining to the atmosphere itself, such as its chemical composition, its weight per unit volume, the law of the relation between pressure, density and temperature, the specific heat of the air, the viscosity, the radiating and absorbing powers, &c.

We need not follow the professor through all the problems that he enumerates calling for increased attention, since every physicist will readily admit that there is a large harvest of information to be gathered in all that concerns the behaviour of the atmosphere, whether at rest or in motion; and every one will find a still larger number of subsidiary problems, awaiting solution, in proportion to the thorough and exhausting character of the work that is bestowed on each main line of investigation. Neither is it necessary to pursue in detail the various topics of applied meteorology, which may at first sight appear somewhat local in their character, but which will be found to apply with very slight modifications to other districts, wherever sufficient enterprise and enlightenment invite the co operation of the physicist in fields of practical utility. It is of more importance, especially in consideration of the matter suggested by the second subject of this article, to see what he has to say concerning the hopefulness of the application of any theory to the problem of the general circulation of the atmosphere. In our wide dependency of India it is necessary at times to deal with imperfect information by imperfect methods; to treat a problem of economic importance with skill based on experience where it is impossible to introduce the certainty that follows mathematical deduction. This course appears to meet with approval, for it is urged that, "for the present at least, it may be wisest to seek for graphic methods and processes of quadrature, which may enable us to arrive at approximate solutions of the complicated systems of equations that represent the interaction of the nine elements that enter into the problem of the motions of the atmosphere." The attitude here suggested is scientific and prudent, and conveys a quiet censure on those who, knowing little of the difficulties that beset the solution, are impatient at the non-fulfilment of forecasts, which the better instructed know are tentative and provisional in their character. To those who exhibit their smartness by immature criticism, we recommend the study of the following paragraph with which Prof. Abbe concludes his review of the general problem. "Add to all these (difficulties) the further consideration that, when once set in motion, the atmosphere may, by some very delicate change in the conditions under which it is moving, assume some obscure form of discontinuous motion, and we at once see that the difficulties of the analytical mechanics of meteorology challenge the intellectual power of man to overcome them."

What, then, is to be said of those, who, occupying a prominent position in journalism, have the opportunity of guiding intelligent opinion, yet use that position with the deliberate intention of discrediting meteorological inquiry and of throwing additional obstacles in the way of those who struggle to solve a problem of enormous magnitude by means of very inadequate data? For this we understand to be the position of Mr. Eliot and his critics, or rather his assailants, for of criticism there is none. It is not contended that an erroneous theory has been pursued, or that some source of information has been overlooked; it is not suggested that any other forecast could have been made from the materials at hand; there is only that kind of cheap sneer, with which we are so painfully familiar, "that all the material which science has so painfully accumulated and laboured over for so many years, can give us no hint of a vital change in the weather, impending at three weeks distance." There is no recognition of the valuable work that the Indian Meteorological Office has inaugurated, and to some extent accomplished, or of the fact that for thirteen consecutive years the forecast of the monsoon has been fairly accurate, and that this is the first conspicuous failure. It seems positively childish to condemn a system which has such a uniformly good record, because in this instance "some obscure form of discontinuous motion" has baffled ingenuity, and disclosed the incompleteness of the data. It is needless to say that Mr. Eliot has a very satisfactory reply to the journalist, or that his reputation stands above any need of our support. The only point which it does seem worth while to make, is to express a regret that a good opportunity has been missed by this influential newspaper for urging upon the Government the necessity of increasing the area over which observations are made, and of educating intelligent opinion as to the direction in which additional information is to be sought. This we conceive to be the proper attitude to assume with regard to the unfortunate forecast. To strengthen the hands of the scientific advisers of the Government would be a worthy and generous motive; to sneer at the energetic officials, and to sow increased distrust on the credibility of weather forecasting, is not only to betray the writer's ignorance, but is criminal, so far as it hinders the collection of data which alone can introduce greater certainty into the forecasts, and give the Government the means of dealing with the enormous suffering that follows the failure of the monsoon rains.

W. E. P.

NOTES.

The death is announced of Prof. E. Beltrami, professor of mathematical physics in the University of Rome, president of the R. Accademia dei Lincei, and correspondant of the Paris Academy of Sciences.

Lord Rayleigh will not deliver the second of his course of lectures on "Polarised Light" at the Royal Institution on Saturday afternoon next (March 10), owing to the sudden death of his mother, the Dowager Lady Rayleigh. There will be no lecture on Saturday afternoon.

The German Society of Naturalists and Physicians will meet this year at Aachen, on September 17–21.

The next meeting of the French Association for the Advancement of Science will be held at Paris, on August 2–9, under the presidency of General Sebert.

Astronomers will regret to see the announcement of the death of Dr. C. T. R. Luther, Director of the Düsseldorf Observatory, and the discoverer of many minor planets.

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